5th High-Energy-Proton Microscopy Workshop

Executive Summary Report

Technical University "Bergakademie" Freiberg,
Freiberg (Sachsen), Germany, April 24-26, 2019

An international panel of collaborators met and discussed the topic of High Energy Proton Microscopy (HEPM), its current status, technical specifications, and the enablement of scientific experiments. The main purpose of the HEPM workshop series[1] is to enhance the exchange of ideas on application of high spatial and temporal resolution proton microscopy for fundamental research as well as on future advances for the optimization of proton microscopy systems. This workshop was focused on defining a class of dynamic material science and plasma physics experiments which could be fielded at GSI/FAIR in Darmstadt to effectively utilize the unique capabilities of the PRIOR microscope for achieving new scientific discoveries.

The workshop was run to allow a flexible environment and encourage the discussion that occurred. The set of about 20 presentations given by scientists from Germany, Russia and USA provides an excellent stocktake on pRad operations and the current science being done at LANL, high-energy proton experiments with PRIOR-I and construction of PRIOR-II at GSI, previous proton microscopy experiments with PUMA at ITEP as well as a good insight into comprehensive computer modeling and advanced design of proton microscopy systems. It also identified future exciting directions where HEPM diagnostics with PRIOR would play the key role such as dynamic materials processing and synthesis, equation-of-state of strongly coupled plasmas and warm dense matter, dynamic liquid-liquid and solid-solid phase transitions, hydrodynamic instabilities, fast loading of porous materials and the kinetics of phase transformations.

The workshop confirmed that the PRIOR-II facility which utilizes intense beams of up 4-5 GeV energy protons delivered by GSI/FAIR synchrotrons can provide a significant step forward in both spatial and temporal resolution (10 μm @ 10 ns) to advance materials research and dense plasma physics already right after its commissioning at GSI in 2020. There was broad agreement at the workshop that among a number of proposed dynamic drivers which could be used at GSI for future PRIOR experiments (e.g. light gas guns, moderate pulsed power generators, lasers), high-explosive (HE) shock wave generators are the most efficient ones and offer the highest discovery potential. In particular, for the first experiments very promising are the ultra-compact HE generators which have been developed for PRIOR at IPCP in Russia in combination with the small blasting chamber (up to 150 g HE) which is already available in Darmstadt.

Finally, in view of above conclusions, the researchers from Freiberg University, GSI (Darmstadt), IPCP (Chernogolovka), ITEP (Moscow) and LANL (Los Alamos) decided to team up and combine their efforts in order to promptly enable HE-driven fundamental physics experiments at the PRIOR facility in Darmstadt ("HE@PRIOR"). Technical and administrative issues of this joint international project were discussed in detail and appropriate solutions were proposed. In particular, exploiting the HE-licenses available in Freiberg shall significantly reduce the level of potential legal difficulties for fielding HE-driven experiments at GSI/FAIR. In the following steps the collaborators will identify the most compelling scientific cases and work out a detailed technical design of the corresponding HE@PRIOR experiments.

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[1] Previous HEPM workshops took place in Darmstadt, Germany (2009), in Chernogolovka, Russia (2010), in Los Alamos, USA (2011) and again in Darmstadt (2013).